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PLASMA APPARATUS AND DRY ETCHING METHOD USING IT

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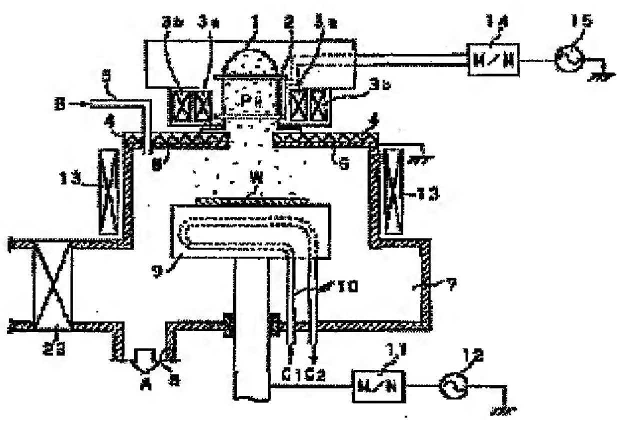
Abstract of **JP7221079**

PURPOSE:To obtain a plasma apparatus in which a high-accuracy minute working operation can be performed by a method wherein at least a part of the inner wall of a high-vacuum container which generates a high-density plasma at a specific ion density inside the container is constituted of an Al-based member and the Al-based member can be heated. CONSTITUTION:At least one plasma generation means which generates a high- density plasma at an ion density of 10<11>/cm<3> or higher inside a high-vacuum container 7 is provided. The high-density plasma which is generated is at least one out of a helicon wave plasma and an inductive-coupling plasma. Then, for example, the ceiling plate 6 of the process chamber 7 for a helicon wave plasma apparatus is constituted of an Al plate, and the Al plate can be heated. The ceiling plate 6 comes into contact with the helicon wave plasma PH which has been extracted into the process chamber 7, and it is used as the supply source of Al. A heater 4 promotes the progress of a chemical reaction on the surface of the ceiling plate 6 in a dry-etching process.



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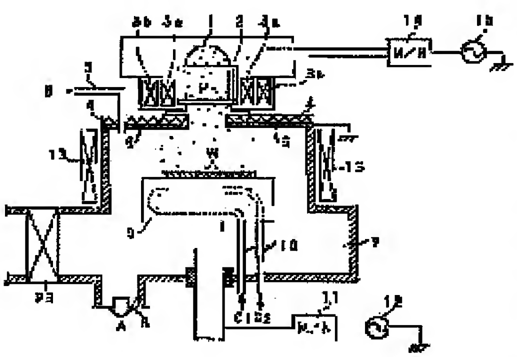
(54) PLASMA APPARATUS AND DRY ETCHING METHOD USING IT



(57)Abstract:
PURPOSE: To obtain a plasma apparatus in which a high-accuracy minute working operation can be performed by a method wherein at least a part of the inner wall of a high-vacuum container which generates a high-density plasma at a specific ion density inside the container is constituted of an Al-based member and the Al-based member can be heated.
CONSTITUTION: At least one plasma generation means which generates a high- density plasma at an ion density of 1011/cm3 or higher inside a high-vacuum container 7 is provided. The high-density plasma which is generated is at least one out of a helicon wave plasma and an inductive-coupling plasma. Then, for example, the ceiling plate 6 of the process chamber 7 for a helicon wave plasma apparatus is constituted of an Al plate, and the Al plate can be heated. The ceiling plate 6 comes into contact with the helicon wave plasma PH which has been extracted into the process chamber 7, and it is used as the supply source of Al. A heater 4 promotes the progress of a chemical reaction on the surface of the ceiling plate 6 in a dry-etching process.

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CLAIMS

[Claim(s)]
[Claim 1] Ion density is 1011-/cm3 in the high vacuum container which holds a substrate, and said high vacuum container. Plasma equipment with which it comes to prepare a heating means to have at least one set of a plasma production means to make the above high density plasma generate, and for a part of internal surface [at least] of said high vacuum container to be constituted using aluminum system member, and to heat this aluminum system member.
[Claim 2] Plasma equipment according to claim 1 characterized by including a helicon wave plasma production means to have the plasma production chamber which goes around with the 1st RF antenna and field generation means, and is connected to said high vacuum container in said plasma production means.
[Claim 3] Plasma equipment according to claim 1 or 2 characterized by including an inductively-coupled-plasma generation means to have the non-conductive member which constitutes some shaft orientations of said high vacuum container, and the 2nd RF antenna wound around the periphery side of this non-conductive member in said plasma production means.
[Claim 4] Said aluminum system member is plasma equipment given in any 1 term of claim 1 characterized by constituting the field which meets said substrate at least among the internal surfaces of said high vacuum container thru/or claim 3.
[Claim 5] The dry etching approach characterized by etching the copper content aluminum system ingredient film on the substrate held in said high vacuum container using chlorine-based gas using plasma equipment given in any 1 term of claim 1 thru/or claim 4.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] For this invention, ion density is 1011-/cm3 about (Aluminum aluminum) system ingredient film containing especially copper (Cu) about the dry etching approach using the plasma equipment and this which are applied to manufacture of a semiconductor device. In case it etches using the above so-called high density plasma, it is related with the equipment and the approach of making it possible to prevent generating of the etch residue resulting from Cu.
[0002]
[Description of the Prior Art] As wiring material film of a semiconductor device, aluminum system ingredient film is used most widely. About this aluminum system ingredient film, attaining the electromigration (EM) resistance which was excellent also compared with the former, and stress migration (SM) resistance with adoption of the multilayer-interconnection structure in a commercial chip is called for. It is becoming indispensable from this background to add Cu on aluminum system ingredient film. Although addition of Cu was performed at the beginning on little level which adds an amount 0.5 more% to aluminum-1%Si, about the wiring film used by the upper layer side rather than the wiring film for substrate contact, adding on a lot of level is also examined by recent years like aluminum-2% Cu or aluminum-4% Cu.
[0003] Generally dry etching of aluminum system wiring film is performed using chlorine-based gas. For example, BCl3 / Cl2 indicated by JP,59-22374,B Mixed gas is the example of representation of this chlorine-based gas. the chemical species which contribute as a main etching kind in etching of aluminum system wiring layer -- Cl* it is -- a spontaneous and very prompt etching reaction is advanced. However, Cl* Since etching advances isotropic, the ion assistant device was used under the conditions which usually give a certain amount of incidence ion energy, and the high anisotropy has been attained.
[0004] About this dry etching, it is called for with advanced detailed-izing of the design rule of a semiconductor

device that it is satisfied with a higher level than before of requirements, such as low-gas-pressure-izing, formation of a high plasma consistency, and reduction [/ near the substrate] in a field. Several kinds of new high density plasma equipments are successively proposed under this situation in recent years. The helicon wave plasma equipment indicated by JP,3-68773,A is one of the equipment which great expectation requires also in this equipment. That plasma production device is a thing of impressing a magnetic field to a cylinder-like chamber, impressing high frequency to the loop antenna further wound around this chamber, making a helicon wave generate in this chamber, accelerating an electron by the energy transport which led the process of Landau damping from this helicon wave, and making this accelerated electron collide with a gas molecule. At the helicon wave plasma, it is 1011-1013-/cm3 about. High ion density can be attained.

[0005] Moreover, the ICP etching system which used inductively coupled plasma (ICP:Inductively Coupled Plasma) is indicated by monthly semiconductor world 1993 year 10 month number p.68-75 (press journal company **). This supplies RF power to the off-resonance multiturn antenna wound around the perimeter of the quartz cylinder which is a plasma production chamber, is rotating an electron according to the field formed inside this antenna, and makes this electron and gas molecule collide by the high probability. According to the ICP, it is 1011-1012-/cm3 about. Ion density can be attained.

[0006]

[Problem(s) to be Solved by the Invention] By the way, in the dry etching of aluminum system wiring film, extensive generating of residue has posed a serious problem with increase of the addition of Cu. This problem is explained referring to drawing 2 and drawing 10 . It is SiO2 as now shown in drawing 2 as an etching sample. The wafer with which aluminum system wiring film 37 was formed on the interlayer insulation film 31, and the resist mask 38 by which patterning was carried out to the predetermined configuration was further formed on this is considered. Here, it comes to carry out the laminating of the barrier metal 34 and the aluminum-4%Cu film 35 with which the above-mentioned aluminum system wiring film 37 consists of a lower layer side from the Ti film 32 and the TiN film 33 toward an upper layer side, and the TiON antireflection film 36 one by one.

[0007] The condition of the wafer after etching this aluminum system wiring film 37 using conventional general chlorine-based gas is shown in drawing 10 . Among drawing, about the ingredient film by which anisotropy processing was carried out, Subscript a is attached to the original sign and it has expressed to it. Although the circuit pattern which has an anisotropy configuration is formed in the part covered by the resist mask 38 of this etching, the needlelike residue 40 occurs in large quantities also into the part which is not covered. For this, Cu contained on the aluminum-4%Cu film 35 is Cl* in the plasma. It is because the aluminum-4%Cu film 35 and a barrier metal 34 remain in the field covered by this micro mask 39 as a result of functioning as a detailed etching mask with which it reacts, a copper chloride with low vapor pressure is generated, and this is called the micro mask 39.

[0008] Then, in order to usually remove this residue 40, the approach of raising the incidence ion energy at the time of etching, and reinforcing the ion sputtering effectiveness is taken. However, under the situation that the yield of residue 40 is increasing with increase of the addition of Cu, it has come to raise the desired removal effectiveness. Even if the equipment with which a high ion current consistency like helicon wave plasma equipment or ICP equipment is obtained is used for this, it does not change fundamentally.

[0009] Or the method of removing residue chemically is reported to the collection of the 37th applied-physics relation union lecture meeting (1990 spring annual conventions) lecture drafts, p.456, and lecture number 28 a-ZF -1 as an approach of removing this residue 40. By performing over etching on direction-conditions -- radical reaction serves as a subject -- this corrodes the needlelike residue 40 also from a longitudinal direction, and specifically tends to remove this. However, although this approach is effective in removal of residue 40, since decomposition removal of micro mask 39 itself cannot be carried out, a possibility that micro mask 39 self may serve as a particle pollution source is large.

[0010] A possibility that it may become difficult especially with helicon wave plasma equipment to perform over etching according to conditions isotropic in this way itself is also large. It is because electron temperature is very high, dissociation of a gas molecule progresses too much with low voltage in high-density plasma [like the helicon wave plasma] this [whose] is, so the amount of generation of a radical has the strong inclination running short although ion is generated superfluously.

[0011] moreover, a 1992 dry-cleaning process symposium abstract collection -- the approach of carrying out volatilization removal of the copper in the form of chloro aluminum complex salt is indicated by p.59-63. Chloro aluminum copper is made to generate by this approach by preparing the secondary electrode covered with the

alumina target on the wall surface of a static magnetron triode RIE system, and making the copper chloride generated in the process which etches the aluminum-Cu alloy film using chlorine-based gas, and the aluminum chloride supplied from an alumina target react on the substrate heated by about 120 degrees C.

[0012] However, since whenever [above-mentioned stoving temperature] is close to the upper limit of the heat-resistant temperature of the resist mask usually used, I want to avoid substrate heating if possible. Thus, in a Prior art, it is difficult to control generating of the residue and particle which face carrying out dry etching of the aluminum system wiring film containing Cu, and originate in Cu. Then, this invention solves these problems and it aims at offering the plasma equipment which can perform highly precise micro processing, and the dry etching approach using this.

[0013]

[Means for Solving the Problem] Since the above-mentioned purpose is attained, this invention is proposed. That is, for the plasma equipment concerning this invention, Ion density is 1011-/cm3 in the high vacuum container which holds a substrate, and said high vacuum container. It comes to prepare a heating means to have at least one set of a plasma production means to make the above high density plasma generate, and for a part of internal surface [at least] of said high vacuum container to be constituted using aluminum system member, and to heat this aluminum system member.

[0014] The above-mentioned aluminum system member can be typically constituted using pure aluminum or an alumina (AlOx). Moreover, as the gestalt, a thin film, sheet metal, or the target for sputtering can use all things.

[0015] The high density plasma made to generate in this invention is at least one side of the helicon wave plasma and ICP. The helicon wave plasma has the plasma production chamber which goes around with the 1st RF antenna and field generation means, and is connected to said high vacuum container, and this high vacuum container can be made to generate it using a helicon wave plasma production means to supply the helicon wave plasma.

[0016] Moreover, ICP has the non-conductive member which constitutes some shaft orientations of said high vacuum container, and the 2nd RF antenna wound around the periphery side of this non-conductive member, and can be made to generate it using an ICP generation means to make ICP generate in this high vacuum container.

[0017] Of course, both plasma can be made to generate if a helicon wave plasma production means and an ICP generation means are put side by side. As for the RF antenna of the above 2nd for exciting ICP, at this time, it is very effective to wind around the symmetry as a core the shaft orientations of the field which said field generation means for generating a helicon wave generates. this makes mutually in agreement the shaft orientations of the field which the field and the 2nd RF antenna which a field generation means generates generate -- the inside of a high vacuum container -- setting -- the plasma -- efficient -- conveying -- and -- this -- it is because consumption of the chemical species by the internal surface of a high vacuum container can be controlled according to the plasma confinement effectiveness by the field which the 2nd RF antenna generates.

[0018] In addition, when making the impression frequency to both antennas the same, in order to prevent interference, especially the thing for which control which shifts a phase mutually is performed is effective, although the RF for plasma excitation is impressed to both the RF antenna of the above 1st, and the 2nd RF antenna. This control can be easily performed using a phase-shifter circuit.

[0019] By the way, if it is the field which can fully contact the above-mentioned high density plasma, which field of the internal surface of a high vacuum container is constituted, but if the above-mentioned aluminum system member makes the field which meets said substrate constitute, it is convenient. In order to make ICP generate especially, when it constitutes some shaft orientations of a high vacuum container from a non-conductive member, the arrangement location of high aluminum system member of practicality is mostly restricted to a substrate opposed face. Moreover, when it is required to secure the field which functions as an opposite ground electrode to substrate bias even when not using an ICP generation means and this aluminum system member that has conductivity is made to serve as the function as this electrode, it is necessary to prepare in a substrate opposed face too.

[0020] Above-mentioned plasma equipment uses and is suitable for the dry etching of the Cu content aluminum system ingredient film on the substrate held in said high vacuum container. As etching gas at this time, well-known chlorine-based gas is used conventionally. Moreover, if the above-mentioned Cu content aluminum system ingredient film is aluminum system ingredient film with which Cu is added for the purpose of the improvement of EM resistance or SM resistance, it will not ask the Cu addition and will not ask the existence of

other alloving elements, such as Si,, either.
[0021]
[Function] The point of this invention is in the point of allotting heated aluminum system member to a part of internal surface [at least] of the high vacuum container of the plasma equipment which can generate either [at least] the helicon wave plasma or ICP. With the ion contained in abundance in the above high density plasma, the spatter of this aluminum system member is carried out, and it can supply aluminum system chemical species in a high vacuum container efficiently.
[0022] When using the helicon wave plasma and ICP together especially, lack of the radical in the former can be compensated with the latter, the ion / radical formation ratio in the plasma can be controlled by this, and an ion assistant device can be used smoothly. This leads also to improvement in an etch rate.
[0023] Moreover, if the above-mentioned aluminum system member is arranged in the field which meets said substrate at least among the internal surfaces of said high vacuum container, a design and manufacture of plasma equipment will become simple. Moreover, since substrate bias is used together at the time of the dry etching using this plasma equipment in many cases, this can be used as a DC earth electrode of the large area to the plasma by arranging aluminum system member in a substrate opposed face. Consequently, the spatter of the wall of a high vacuum container can be suppressed to the minimum, and the stable discharge can be made to continue covering a large area.
[0024] If the Cu content aluminum system ingredient film is etched using chlorine-based gas within the above-mentioned high vacuum container, a lot of aluminum chlorides will generate on the front face of aluminum system member put to the chlorine-based chemical species of high density. This aluminum chloride reacts under the copper chloride emitted into the plasma as an etching resultant, and heating conditions, and is aluminum2 CuCl8. It changes and volatilization removal is carried out in the form of this complex salt. Therefore, there is no possibility that residue may occur like the conventional etching. And in this invention, in order not to heat a wafer unlike the conventional technique of similarly using chloro aluminum copper, a problem does not arise at all in use of a resist mask.
[0025]
[Example] Hereafter, the concrete example of this invention is explained.
[0026] Example 1 this example explains the example of 1 configuration of the helicon wave plasma etching system which applied this invention. The notional configuration of this etching system is shown in drawing 1 . This equipment constitutes the top-plate part of the process chamber which is the high vacuum container of a helicon wave plasma etching system from an aluminum plate, and heats this at a heater from a rear-face side.
[0027] First, the helicon wave plasma production section is the helicon wave plasma PH to the interior. It has the bell jar 1 which consists of a non-conductive ingredient for making it generate, and two loop formations which go this bell jar 1 around. It is prepared so that the loop antenna 2 for carrying out coupling of the RF power to the plasma and the above-mentioned chamber 1 may be gone around. inner circumference side solenoid coil 3a which is made to generate the field in alignment with the shaft orientations of this chamber 1, and contributes mainly to propagation of a helicon wave -- and -- mainly -- helicon wave plasma PH Let periphery side solenoid coil 3b which contributes to transportation be the main components.
[0028] Here, the component of the above-mentioned bell jar 1 was used as the quartz. RF power is impressed to the above-mentioned loop antenna 2 through the 1st matching network (M/N) 14 for impedance matching from the RF power source 15 for plasma excitation, and the current of the direction of the circumference of reverse flows mutually to the loop formation of two upper and lower sides. Here, the frequency of the above-mentioned RF power source 15 for plasma excitation was set to 13.56MHz. In addition, the distance between both loop formations is optimized according to the wave number of a desired helicon wave.
[0029] It connects with the process chamber 7, the emission field which the above-mentioned inner circumference side solenoid coil 3a and periphery side solenoid coil 3b form is met, and the above-mentioned bell jar 1 is the helicon wave plasma PH to the interior of this process chamber 7. It is made as [pull]. The side-attachment-wall side and base of the process chamber 7 are constituted using conductive ingredients, such as stainless steel. The interior receives supply of required gas in dry etching from the gas supply line 5 in which high vacuum exhaust air is carried out in the direction of arrow-head A through the exhaust hole 8 by the exhaust system which is not illustrated and by which opening is carried out to the upside top plate 6 in the direction of arrow-head B, and is connected to the load lock chamber which is not further illustrated through a gate valve 23 in the side-attachment-wall side.

[0030] Furthermore, the conductive substrate stage 9 electrically insulated from that wall surface is held in the interior of the process chamber 7, and it is made as [perform / hold for example the wafer W as a processed substrate, and / on this / predetermined dry etching]. Supply of a refrigerant is received in the above-mentioned substrate stage 9 from the chiller which is not illustrated in order to maintain the wafer W in a process to desired temperature, and they are an arrow head C1 and C2 about this. The cooling piping 10 for circulating a direction is inserted in.
[0031] In order to control the energy of the ion which carries out incidence out of the plasma, the RF power source 12 for bias impression which impresses substrate bias is connected to Wafer W through the 2nd matching network (M/N) 11 on the above-mentioned substrate stage 9. Here, the frequency of the RF power source 12 for bias impression was set to 13.56MHz. Furthermore, in order to complete the emission field in the about nine above-mentioned substrate stage, the magnet 13 which can generate a multi-cusp field as an auxiliary field generation means is arranged in the exterior of the above-mentioned process chamber 7.
[0032] Although the configuration so far is similar with the configuration of the conventional helicon wave plasma etching system, the parts which make the special feature of this Dorati etching system are a top plate 6 and the heater 4 which heats this from a rear-face side. The above-mentioned top plate 6 is the helicon wave plasma PH pulled out into the process chamber 7. It functions as a source of supply of aluminum by contacting. Moreover, since it is in parallel physical relationship geometrically to the substrate stage 9 where substrate bias is impressed, it was functioning also as a DC earth electrode to the plasma, consumption of the plasma chemistry kind by the internal surface of the process chamber 7 was held down, and it has contributed to continuation of stable discharge. Moreover, the above-mentioned heater 4 is contributed to promoting advance of the chemical reaction in the front face of a top plate 6 in the process of dry etching.
[0033] In example 2 this example, aluminum system wiring film containing the aluminum-4%Cu film was etched using the etching system stated in the example 1. This process is explained referring to drawing 2 and drawing 3. The important section cross section of the wafer used as an etching sample of this example is shown in drawing 2. This wafer is SiOx. aluminum system wiring film 37 is formed on an interlayer insulation film 31, and the resist mask 38 is further formed with a predetermined pattern on this. Here, the laminating of the barrier metal 34, the aluminum-4%Cu film 35, and the TiON antireflection film 36 of Ti system is carried out one by one, and, as for the above-mentioned aluminum system wiring film 37, the laminating of the Ti film 32 and the TiN film 33 is further carried out to order for example, from a lower layer side, as for the barrier metal 34 of the above-mentioned Ti system.
[0034] Moreover, the above-mentioned resist mask 38 is formed in pattern width of face of 0.25 micrometers through the KrF excimer laser lithography which used for example, the chemistry multiplier system resist ingredient.
[0035] This wafer was set on the substrate stage 9 of the above-mentioned etching system. Moreover, the top plate 6 was heated at about 250 degrees C using the heater 4. In this condition, they were first etched on condition that the following, having used the TiON antireflection film 36 and the aluminum-4%Cu film 35 as an example.
BCl3 Flow rate 60 SCCMCl2 Flow rate 90 SCCM gas pressure 0.13 Pa source power (PH excitation) 2000 W (13.56 MHz)
RF bias power 150 W (13.56 MHz)
Substrate stage temperature 20 ** (water cooling)
[0036] At this process, it is the helicon wave plasma PH. A lot of AlClx from the top plate 6 heated by contacting the chlorine-based chemical species which exist in large quantities in inside It was supplied. CuClx with the low vapor pressure generated with etching of the aluminum-4%Cu film 35 This AlClx It reacted, changed to chloro aluminum copper with high vapor pressure, and was removed promptly. Therefore, as shown to drawing 3 by this etching, aluminum system circuit pattern 37a which has a good anisotropy configuration was able to be obtained. In addition, about what has an anisotropy (anisotropic) configuration among the patterns of each ingredient film obtained after etching, Subscript a is attached and expressed to the sign of the original ingredient film (the following -- the same .). No particle contamination in needlelike residue like before or the process chamber 7 was produced.
[0037] By example 3 this example, the ICP generation section is further added to the helicon wave plasma etching system mentioned above in the example 1, and the etching system of the hybrid mold which made it possible to make coincidence generate the helicon wave plasma and ICP is explained. The notional

configuration of this etching system is shown in drawing 4 . This equipment prepares the ICP generation section in the top field of the process chamber which is a high vacuum container to the field of the helicon wave plasma production section and its downstream, and has the configuration made as [supply / through a control means / from the RF power source 15 for plasma excitation common to both / these / the generation section / source power].

[0038] The cylinder 16 which consists of a non-conductive ingredient which occupies some shaft orientations [some] of the conductive chamber wall of the process chamber 7, i.e., side-attachment-wall side of a cylindrical shape, and the multiturn antenna 17 wound around the periphery side are contained in the above-mentioned ICP generation section. Here, the component of the above-mentioned cylinder 16 was used as the quartz. The above-mentioned multiturn antenna 17 is connected to the RF power source 15 for plasma excitation through the 3rd matching network 18, the phase shifter 19, and the switch 21. The number of turns of this multiturn antenna 17 is optimized according to conditions, such as a diameter of a cylinder 16, and RF frequency to impress.

[0039] On the other hand, in connection with having formed the above-mentioned switch 21, a switch 20 is formed also between the RF power source 15 for plasma excitation, and the 1st matching network 14, and it is the helicon wave plasma PH. The RF impression to the loop antenna 2 to excite was controlled. In addition, by the ability shifting the phase of the RF impressed to the above-mentioned loop antenna 2 and the above-mentioned multiturn antenna 17 a term 1/2 round, the above-mentioned phase shifter 19 prevents interference of both RFs, and realizes stable plasma discharge.

[0040] The above-mentioned bell jar 1, the cylinder 16, the multiturn antenna 17, Wafer W, etc. are altogether arranged in same axle about the shaft of the process chamber 7. For this reason, the magnetic field which the above-mentioned multiturn antenna 17 generates is the helicon wave plasma PH diffused from the above-mentioned bell jar 1. It makes it possible to give uniform dry etching to Wafer W, demonstrating the effectiveness which shuts this up and controlling consumption of chemical species with a chamber wall, while pulling out efficiently.

[0041] In addition, the magnet 22 for completing the emission field near the wafer W still more strictly is attached around the periphery side of the process chamber 7 which can set a cylinder 16 caudad. The arrangement location of this magnet 22 may not be restricted to the example illustrated, for example, may be other locations, such as a perimeter of the stanchion of the substrate stage 9. furthermore, it is -- it is -- this may be transposed to the solenoid coil for mirror magnetic field formation.

[0042] It sets to this equipment and is the helicon wave plasma PH. Inductively-coupled-plasma PI In order to make coincidence generate, as shown in drawing 4 , both the switches 20 and 21 are set to ON. Helicon wave plasma PH diffused from the bell jar 1 inside the process chamber 7 at this time Inductively-coupled-plasma PI which the gas introduced from a gas supply line 5 was newly dissociated by inductive-coupling discharge, and generated It lives together. Since the phase of the RF impressed to a loop antenna 2 and the multiturn antenna 17 at this time is shifted the term 1/2 round mutually, stable discharge continues it.

[0043] On the other hand, it is the helicon wave plasma PH. As shown in drawing 5 , a switch 20 is set to ON and a switch 21 is set to OFF to generate. Thereby, the plasma which exists in the process chamber 7 is the helicon wave plasma PH diffused from the bell jar 1. It becomes. In addition, the explanation with a drawing is setting a switch 20 to OFF and setting a switch 21 to ON in the etching system which has an above-mentioned configuration, although omitted, and is inductively-coupled-plasma PI., of course, it is possible to also make it generate.

[0044] In example 4 this example, the aluminum/W system laminating wiring film was etched using the etching system of the hybrid mold mentioned above in the example 3. This process is explained referring to drawing 6 thru/or drawing 8 . The important section cross section of the wafer used as an etching sample of this example is shown in drawing 6 . This wafer is SiOx. The aluminum/W system laminating wiring film 48 is formed on an interlayer insulation film 41, and the resist mask 49 is further formed with a predetermined pattern on this. Here, the laminating of the barrier metal 44, the W film 45, the aluminum-4%Cu film 46, and the TiON antireflection film 47 of Ti system is carried out one by one, and, as for the above-mentioned aluminum/W system laminating wiring film 48, the laminating of the Ti film 42 and the TiN film 43 is further carried out to order for example, from a lower layer side, as for the barrier metal 44 of the above-mentioned Ti system.

[0045] Moreover, the above-mentioned resist mask 49 is formed in pattern width of face of 0.25 micrometers through the KrF excimer laser lithography which used for example, the chemistry multiplier system resist ingredient.

[0046] It set on the substrate stage 9 of the etching system which stated this wafer in the example 3, as shown in drawing 4 , both the switches 20 and 21 were set to ON, and they were first etched on condition that the following, having used the TiON antireflection film 47 and the aluminum-4%Cu film 46 as an example. In addition, the frequency of the RF power source 12 for bias impression was set to 2MHz here.
BCl3 Flow rate 80 SCCMCl2 Flow rate 120 SCCM gas pressure 0.13 Pa source power (PH and PI excitation) -- 2500 W (13.56 MHz)
RF bias power 100 W (2 MHz)
Substrate stage temperature 20 ** (water cooling)
Here, it is the helicon wave plasma PH. The ion contained in abundance, and inductively-coupled-plasma PI The ion assistant device by the radical contained in abundance worked smoothly, and Cu was removed promptly. Consequently, TiON antireflection film pattern 47a and aluminum-4%Cu film pattern 46a which have a good anisotropy configuration were obtained, without generating residue and particle, as shown in drawing 7 .
[0047] Next, helicon wave plasma PH In order to use and to etch the W film 45 and barrier metal 44 which remain, as shown in drawing 5 , the switch 21 was set to OFF, and it etched on condition that the following as an example.
SF6 Flow rate 30 SCCMCl2 Flow rate 20 SCCM gas pressure 0.13 Pa source power (PH) 2500 W (13.56 MHz)
RF bias power 100 W (2 MHz)
substrate stage temperature 20 ** -- the W film 45, the TiN film 43, and the Ti film 42 which are originally etched by Mohd near ion sputtering in this process -- helicon wave plasma PH It was promptly etched with inner abundant ion. And since there were few amounts of radical formation, an undercut was not generated on the W film 45 at the time of over etching.
[0048] Consequently, as finally shown in drawing 8 , aluminum system circuit pattern 36a which has a good anisotropy configuration was able to be obtained.
[0049] Example 5 this example explains the example of 1 configuration of the ICP etching system which applied this invention. The notional configuration of this etching system is shown in drawing 9 . Although most consists of conductive ingredients, such as stainless steel, for the wall surface of the process chamber 54 of this equipment, some shaft orientations are used as the cylinder 53 which consists of a quartz, and the multiturn antenna 58 is wound around this periphery side. A RF is impressed to this multiturn antenna 58 through the 1st matching network (M/N) 59 from the RF power source 60 for plasma excitation. Here, the frequency of the above-mentioned RF power source 60 for plasma excitation was set to 2MHz.
[0050] High vacuum exhaust air is carried out in the direction of arrow-head D through the exhaust hole 55 by the exhaust system which is not illustrated, and the interior of the above-mentioned process chamber 54 is made by dry etching as [receive / supply of required gas] in the direction of arrow-head E from the gas supply line 57 by which opening is carried out to a base. The process chamber 54 has held the conductive substrate stage 56 electrically insulated from that wall surface again, and is made as [perform / hold for example, the wafer W as a processed substrate, and / on this, / predetermined dry etching]. In the above-mentioned substrate stage 56, it is inductively-coupled-plasma PI. In order to control the energy of the ion which carries out incidence from inside, the RF power source 62 for bias impression which impresses substrate bias is connected to Wafer W through the 2nd matching network (M/N) 61. More here than the frequency of the above-mentioned RF power source 60 for plasma excitation, in order to prevent interference, the frequency of the RF power source 62 for bias impression was lowered a little, and was set to 1.8MHz.
[0051] Furthermore, the top cover of the above-mentioned process chamber 54 consists of top plates 52 which consist of aluminum, and this top plate 52 is made as [heat / from a rear-face side / at a heater 51]. This top plate 52 is PI to inductively coupled plasma. While functioning as a DC earth electrode to receive, at the time of etching, it becomes the source of supply of aluminum. If aluminum-4%Cu film which was mentioned above in the example 2 or the example 4 using the ICP etching system of this example is etched, it is CuClx in the front face of a top plate 52. AlClx A reaction occurs. Therefore, the residue and particle originating in Cu can be prevented and good high-speed anisotropy processing can be performed.
[0052] As mentioned above, although this invention was explained based on the example of five examples, this invention is not limited to these examples at all. For example, although both the frequencies of the object for helicon wave plasma excitation of an etching system and the source power for ICP excitation were set to 13.56MHz in the above-mentioned example, a different frequency among both may be used. In this case, especially a phase shifter is unnecessary. Moreover, since the electron of a specific class is accelerable with an

impression frequency in the case of the helicon wave plasma, the optimal frequency can also be chosen according to the class of process made into the purpose.

[0053] In addition, it cannot be overemphasized that the configuration of an etching system, the configuration of a sample wafer, and the details of dry etching conditions can change suitably.

[0054]

[Effect of the Invention] It can carry out without moreover heating a substrate to an elevated temperature without generating the residue and particle which originate etching of the Cu content aluminum system ingredient film in Cu, if this invention is applied so that clearly also from the above explanation. And since this high precision etching is realizable with the comparatively simple configuration of preparing aluminum system member in a part of internal surface of the process chamber of high density plasma equipment, and heating this, economical efficiency is also very high.

[0055] Therefore, it contributes to high integration of a semiconductor device, and high reliance-ization greatly through this invention raising remarkably practical use worth of Cu content aluminum system ingredient film, and making the dry etching highly precise.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the outline sectional view showing the example of 1 configuration of the helicon wave plasma etching system constituted with the application of this invention.

[Drawing 2] In the process which applied this invention to the dry etching of aluminum system wiring film, it is the typical sectional view showing the condition of the wafer before etching.

[Drawing 3] It is the typical sectional view showing the condition of having etched aluminum system wiring film of drawing 2 .

[Drawing 4] In the plasma etching system of the hybrid mold constituted with the application of this invention, it is the outline sectional view showing the condition of having excited both the helicon wave plasma and ICP.

[Drawing 5] It is the outline sectional view showing the condition of having excited only the helicon wave plasma, in the plasma etching system of a hybrid mold similarly.

[Drawing 6] In the process which applied this invention to the dry etching of the aluminum/W system laminating wiring film, it is the typical sectional view showing the condition of the wafer before etching.

[Drawing 7] It is the typical sectional view showing the condition of having etched the TiON antireflection film of drawing 6 , and the aluminum-4%Cu film.

[Drawing 8] It is the typical sectional view showing the condition of having etched W film and the barrier metal of drawing 7 .

[Drawing 9] It is the outline sectional view showing the example of 1 configuration of the ICP plasma etching system constituted with the application of this invention.

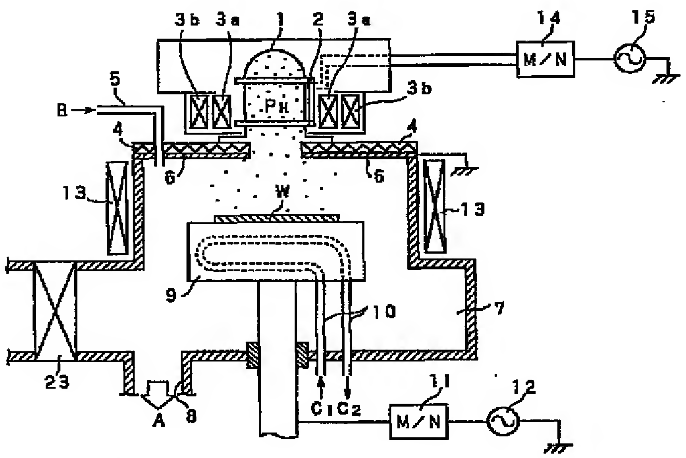
[Drawing 10] In the dry etching of the conventional Cu content aluminum system wiring film, it is the typical sectional view showing the condition that the residue originating in Cu occurred.

[Description of Notations]

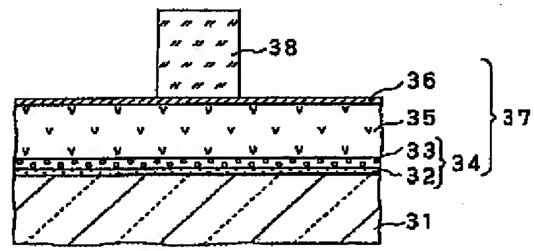
1 Bell Jar
2 Loop Antenna
3a Inner circumference side solenoid coil
3b Periphery side solenoid coil
4 51 Heater
6 52 Top plate
7 54 Process chamber
9 56 Substrate stage
12 62 RF power source for bias impression
15 60 RF power source for plasma excitation
16 53 Cylinder
17 58 Multiturn antenna
35 46 aluminum-4%Cu film
W Wafer

DRAWINGS

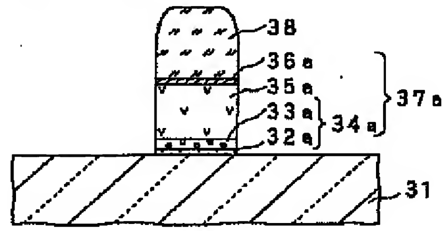
[Drawing 1]



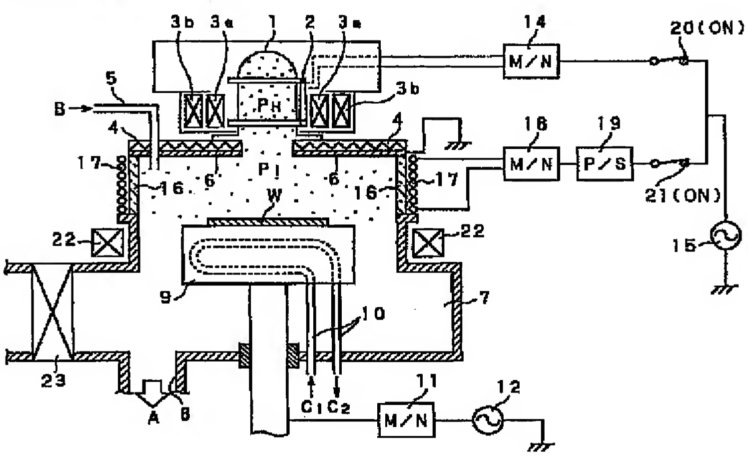
[Drawing 2]



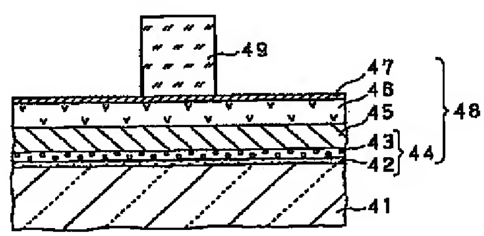
[Drawing 3]



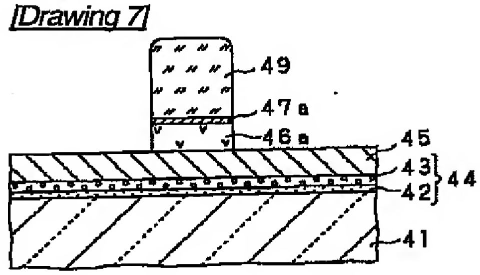
[Drawing 4]



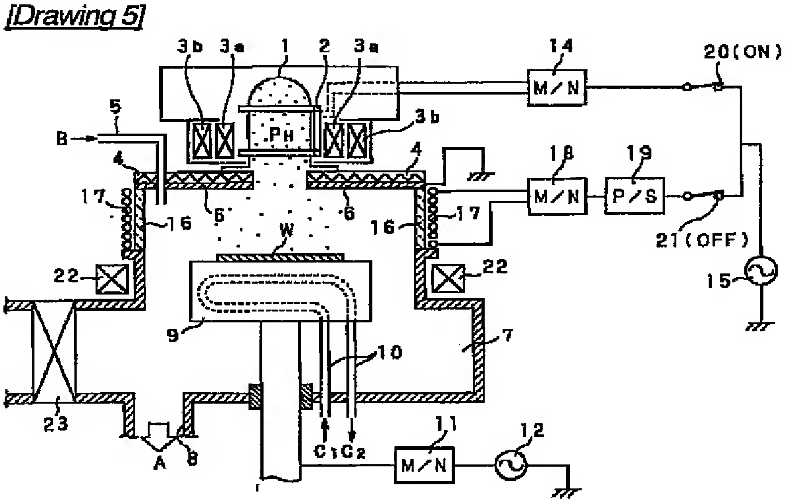
[Drawing 6]



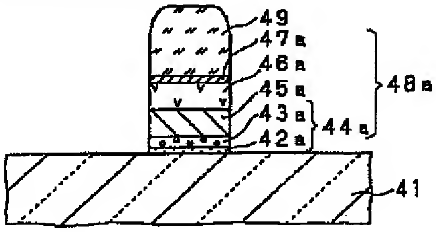
[Drawing 7]



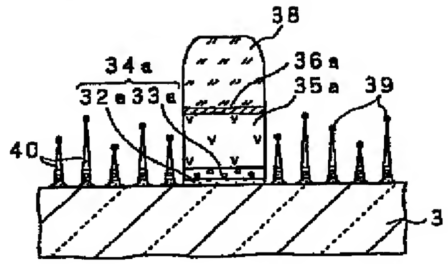
[Drawing 5]



[Drawing 8]



[Drawing 10]



[Drawing 9]